A STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE WITH PARTIAL REPLACEMENT OF COURSE AGGREGATE BY DEMOLISHED CONCRETE WASTE

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ABSTRACT- *The rapid growth of construction activities has led to a significant increase in demolition waste concrete and serious environmental and ecological challenges. Improper disposal of demolition concrete occupies valuable land but also contributes to environmental degradation. Recycling and reusing this waste concrete material in concrete production offers a sustainable and economical solution. In this study, strength of the concrete is investigated experimentally by replacing a part of natural coarse aggregate(NCA) with (RCA)recycled demolished concrete aggregate (RCA). M30 grade concrete is utilized with coarse aggregate(CA) replacement levels of 25% and 50% by weight. Demolition waste concrete from a five-year-old building was collected, processed and converted into recyclable aggregate. Eighteen cube examples were produced, six for regular concrete, six for 25% RCA and six for 50% RCA. The compressive strength of RCA concrete was evaluated at, seven, fourteen and twenty-eight days and compared to conventional concrete. The findings suggest that demolition waste can be used as coarse aggregate in non-structural concrete applications with adequate strength and is a good alternative. The cost study has shown that the use of crushed recycled concrete aggregate reduces the total cost of concrete production. The study suggests that concrete containing 25% and 50% recycled aggregate can be successfully used to build park walkways, college campuses and similar locations, promoting environmentally friendly and sustainable building practices.*

Key Words: Nca, Rca, M30, Ca.

1. INTRODUCTION

1.1 GENERAL

Concrete is one the bulk material used building construction in the world, with production above 4.4 billion tons annually, driven by population growth, infrastructure development and urbanization. The basic ingredients of concrete – cement, fine aggregate(FA) & coarse aggregate(CA) – are being taken from the environment at an unsustainable rate. Of these, aggregates are the most consumed, accounting for 60 to 75 percent of the total volume of concrete. The renovation and modernization of aging infrastructure has been accompanied by a skyrocketing of construction and demolition (C&D) waste. Every year, millions of tons of concrete debris are produced from the demolition of old, damaged or structurally unsound roads, bridges and buildings for new construction. In many poor countries, this garbage is often dumped in landfills. reducing the available land and creating environmental risks. The improper disposal of demolition waste results in serious environmental problems and the extensive mining of natural aggregates (stones and gravel) damages the ecosystem. The lack of natural resources & the disposal of waste products are a two-fold problem. Thus, the concept of "sustainability" in the construction industry has resulted in the requirement of alternative materials to substitute traditional coarse aggregates.

1.2 ENVIRONMENTAL PROBLEMS

The huge quantity of concrete waste from demolitions has resulted in serious environmental problems such as depletion of resources, overburdening of landfills and several types of pollution. Concrete dumped in a landfill instead of being recycled takes up a lot of wasted space for other garbage. Large quantities of natural aggregates have to be mined to make new concrete. The lack of recycling of old concrete only quickens the depletion of natural resources.

Massive volume of concrete dust and particulate matter is also produced during the demolition operations which deteriorates the quality of air and puts adjacent people and workers at risk for respiratory problems. Concrete waste can pollute water supplies by adding harmful, high pH materials to the groundwater and soil, especially when mixed with the other building waste. Finally, the giant transportation and destruction machines contribute to climate change through the release of greenhouse gases and the noise pollution.

Demolition waste causes heavy pollution that should be air pollution, water pollution, and land degradation due to the improper dumping of demolition waste.

It is commonly seen that air and water pollution occurs where the demolition waste damped, large amount of dust, and toxic leachate into water and water bodies, large amount of concrete demolition waste dumping can lead to the destruction ecosystems.

1.3 DEMOLISED CONCRETE WASTE

Demolition concrete waste is the waste generated by the demolition or renovation of buildings, roads, bridges and other civil infrastructures, and constitutes a significant fraction of Construction and Demolition (C&D) debris. The quick production of this heavy inert material causes the serious environmental problems with increasing urbanization, such as the exhaustion of natural aggregate resources and the saturation of landfill capacities.

However, this waste is a valuable, underutilized resource that can be processed and recycled to produce [Recycled Concrete Aggregates] (RCA) or fill materials, reducing the need for virgin aggregates and reducing construction costs. Proper management and recycling of demolished concrete, such as crushing it into aggregates for use as road base, sub-base or in new concrete applications supports not only environmental sustainability through a reduction in carbon footprints, but also the circular economy model by turning waste into a functional, durable construction.

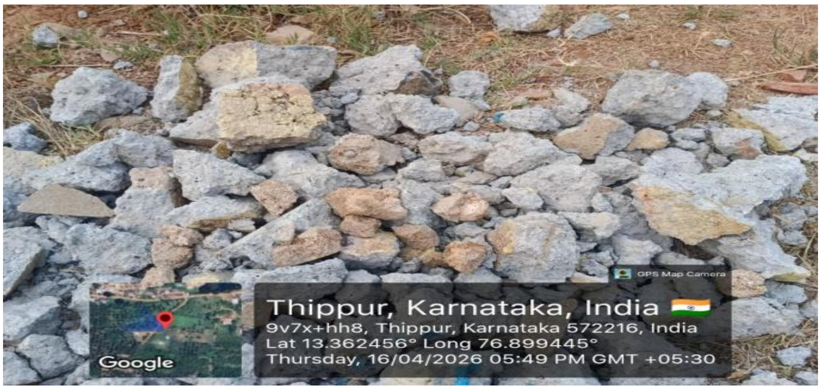

Fig 1.1 Demolished Concrete Wastes

1.4 NECESSITY IN CIVIL ENGINEERING

The generation of demolished concrete waste is a serious environmental and economic issue for the world construction industry with increasing urbanization and continuous replacement of aging structures. The demand for a new building materials like natural coarse aggregate is increasing at an alarming rate and depleting the natural resources. Recycling of the demolished concrete as new infrastructure construction materials has now become a crucial requirement in the infrastructure development to support the sustainable growth.

The re-utilization of this trash as a blending agent for natural coarse aggregate reduces landfill loading, prevents chemical emissions to the land and significantly reduces energy and construction costs. The material characteristics (water absorption, compressive strength, etc.) of the concrete are carefully controlled. The Recent research shows that demolished concrete can be cleaned and crushed, and used as a good alternative for structural purposes.

Environmental Benefits of Recycling Demolished Concrete Waste Sustainability: Less need for stone mining and no habitat destruction from exploitation of constituent materials. Waste management reduces the quantity of non-biodegradable trash that will go to landfills, which is expected to reach billions of tons each year by 2025.Economic viability: It lowers the cost of the source of the materials & the transportation involved which reduces the overall cost of the project. Resource Conservation: The use of recycled coarse aggregates & fine aggregates aids in the preservation of natural sand & gravel for future generations.

1.5 OBJECTIVES

1) To design the M30 grade concrete incorporating partial replacement of coarse aggregate by demolition concrete waste.
2) To study the workability characteristics of natural and recycled aggregate concrete.
3) To find out the load bearing capacity of the concrete specimens after 7,14 and 28 days of curing.
4) To compare the strength properties of standard normal concrete and concrete with 25 % and 50 % demolished concrete waste.
5) To carry out a cost analysis of conventional concrete and recycled coarse aggregate concrete mixes to determine the economic benefits of using demolished concrete waste.

2. LITERATURE REVIEW

2.1 GENERAL

The literature review provides a critical assessment of previous research, identifies gaps, summarizes key findings, and provides a foundation for further scholarly research.

2.2 Dr. Ramakrishna Hegde et al, (June 2018)[1] In their paper Explained that, The cleared garbage is usually dumped in the dumping yard or in low-lying areas. Every year, the generation of large amounts of construction & demolition waste takes place. The disposal of the waste is ongoing a big issue as these waste products require a large area to dump. Moreover, the continuous consumption of virgin materials for the production of ordinary concrete decreases their availability and increases the price of coarse aggregate. From the experimental outcome of the project the following conclusion that the test outcome for concrete with fresh aggregate and concrete with demolished aggregate indicated that the crushing strength of the demolished concrete was marginally lower than that of the conventional concrete. crushing strength was found to be more than 30 N/mm2 up to (30%) replacement of new coarse aggregate. When 50% was substituted with higher than the desired value of 26.6 N/mm^2, the crushing strength was found that 27.11 N/mm^2. Hence this concrete is more suitable for the routine construction projects up to (50%) replacement. The compressive resistance of a concrete with 100% replaced destroyed aggregates after four weeks of the curing was found to be 23.11 N/mm2. In short-term projects such as building sites, ditches, low height retaining walls, etc. where the stress on the structure is relatively less concrete with 100% destroyed aggregate can be used. We'll make concrete from demolished debris at low cost."? So, the total cost of the project will be decreased.

2.3 Pulakit Meshram, Ashwini R. Patil, et al, (2019)[2] In their paper they Explained that, The writing audit of this paper is particularly focused on the improvement approach for RCA from development and destruction wastes. Pozzolanic materials are an attractive and practical way to raise the structural integrity of concrete, either mixed into concrete or applied as a coating on the RA. Research will be conducted using a two-dimensional approach to evaluate the quality and potential auxiliary applications of the rice husk debris with a constant degree of reused aggregates for all blends.

2.4 Swaran dhar et al, (December 2020)[3] In 7 days 65% strength is gained but this strength is not desirable as M30 grade should provide 20 N/mm2 of strength after seven days but only 50% of that is gained. Hence it is clear that using 100% RA for M30 grade will not give the desired strength rather trials with varying proportions should be carried out. The strength obtained after 28 days has doubled during the tests also. RAC has achieved a reasonable strength, but it is currently unfeasible for standard construction practices. It is therefore necessary to do trials with different quantities. various features like permeability, strength with respect to age and their role in durability of concrete, findings Further, suggestions are provided below: The long term performance of these aggregates determines the age limit of RAC. Natural Sand(NS) & old hard recycled concrete with a nominal maximum size of 16 mm are used as the coarse aggregate(CA). The properties of the reinforcing steel corrosion resistance, chloride penetration and salt scaling of RCA concrete should be able to meet standards expected from natural aggregates to improve the effectiveness of structural concrete. On the contrary, strength of the OC-RCA was sufficient and quite close to the pure materials.

2.5 Suresh Sankaranarayannan (2021)[4] In his paper demonstrated that, The concrete specimens were casted by (OPC)ordinary Portland cement grade 53 to achieve the desired compressive strength values in present investigation. Natural aggregates are protected, landfill impact is reduced and money is saved on aggregate, waste product and waste disposal transportation by using destroyed debris as coarse aggregate (CA). Reduces impact on residential landfill space, disposal costs, and potentially reduces overall project costs. It is reported in journals that the crushing strength reduces with increase in the fraction of (RCA) replacement. However, we used destroyed garbage as CA in our study, so the strength was increased up to 40% before the strength decreased. The use of concrete hydrated particles as mortar, correct compaction, partial substitution of natural aggregates & the use of a low w/c ratio of 0.45 resulted in strength values above the desired compressive strength 26.6 Mpa. Bulk density and water absorption of RCA replaced mixes are higher than conventional mixes but still within acceptable limits.

2.6 Bhanu Chaudhary et al, (2022)[5] In current research, the properties of concrete containing natural aggregates and concrete containing varying proportions of recycled aggregates (RCA) were studied. The main conclusion, the recycled demolished aggregate showed a high cementitious potential when reacting with water, due to presence of additional cementitous particles. strength properties of destroyed many strength tests such as split tensile, flexural & (UPV) tests were conducted to determine.

GAP OF THE PROJECT

- There is lack of research on M30 grade concrete with demolished concrete waste but most of the earlier work has been on standard concrete grades.
- Past inquiry have been indicated sufficient strength up to 30% replacement of recycled aggregate. But, comparative studies between 25% and 50% replacement level in M30 concrete is less.
- Preceding study have revealed that different characteristics of demolished concrete waste affect strength. However, there is no proper examination with concrete waste from real demolished buildings.
- Most researchers concluded that higher percentages of replacement weaken M30 concrete but how 50% demolished concrete waste behave in real world construction environment is unknown.
- Environmental benefits of reduction of usage of natural aggregate & usage of 25% and 50% of a recycled aggregate in construction have been delta with in previous studies, but still in-depth study on these topics is needed.
- The present work aims to investigate the strength of M30 concrete by substituting 25% and 50% of natural coarse aggregate with the crushed concrete waste to assess the feasibility of utilizing recycled aggregate concrete in sustainable construction approaches.

3. METHODOLOGY

The overall works carried out in my thesis is demonstrated in the form of flow chart as given below.

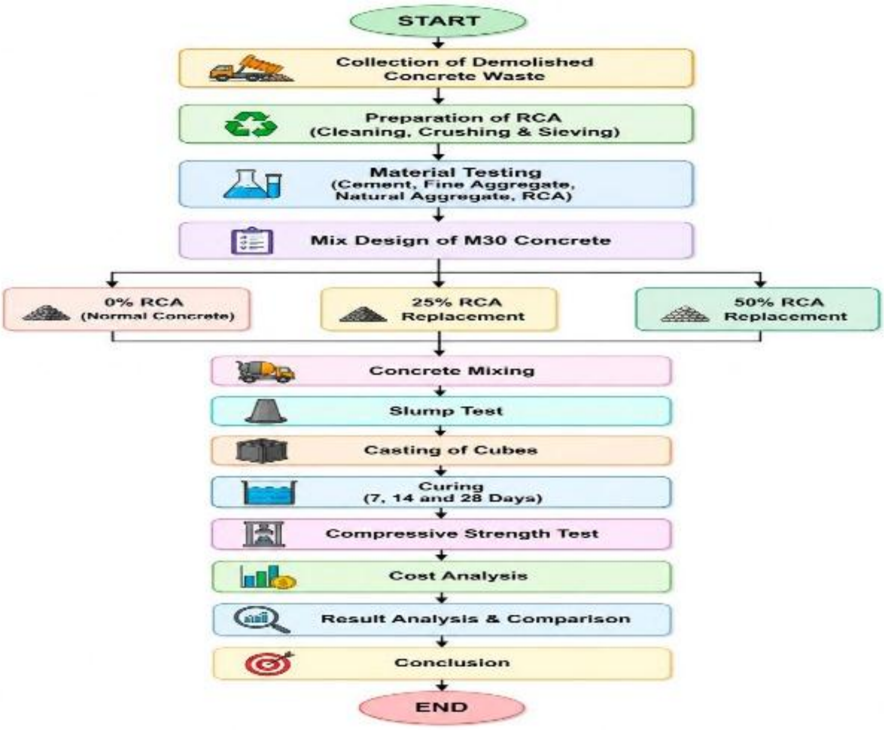

Fig 1: Flow chart

3.1 PREPARATION OF DEMOLISHED CONCRETE AGGREGATE

The demolished concrete aggregate (DCA) used in this examination was taken from the chajja portion of a demolished building of age five years. The concrete waste from the chajja that was destroyed was selected as it contains solidified concrete which could be taken as recycled coarse aggregate. The gathered pieces of demolished concrete were firstly carefully checked and cleaned to remove any undesirable elements such as dust, soil, loose mortar, steel fragments and other impurities. To improve the quality and functionality of the recycled aggregate concrete, the destroyed concrete waste had to be properly cleaned.

Physical breakdown and cutting into finer fractions optimized for the preparation of concrete aggregate was conducted after the removal of impurities and destruction of concrete waste. The size of coarse aggregate required was then obtained by passing the crushed concrete particles through standard IS sieves. The obtained aggregates were cleaned with clean water to remove surface dust and adherent fine particles. The recycled aggregates usually show a higher water absorption due to the previous attached mortar. They were soaked in water for a whole day before being used in concrete mixing.

After the soaking process, the recycled aggregates were extracted and left to dry in room temperature. This process helped to prevent excess water absorption during mixing of concrete and to attain a saturated surface dry condition. The strength & longevity properties of recycled aggregate concrete(RCA) were analysed using prepared demolished concrete aggregates as a partial substitute of natural coarse aggregate(NCA) in M30 grade concrete at replacement levels of 25% and 50%.

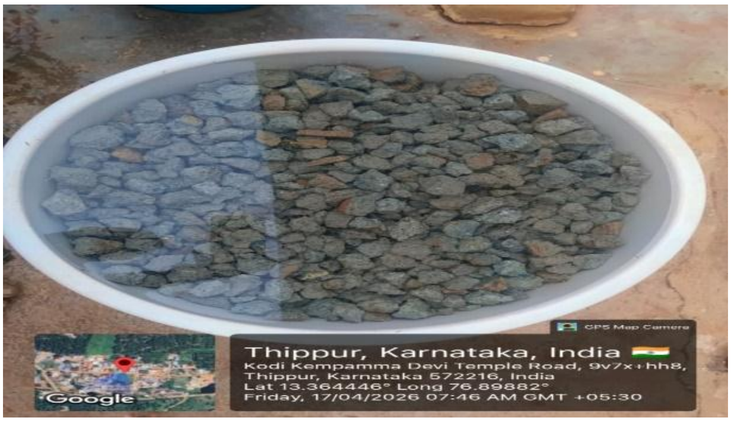

Fig 2 Soaking of demolished concrete

3.2 RESULTS ON TEST OF MATERIALS

3.2.1 TESTS ON CEMENT:

Table 1 Test on the cement materials

Sl. No.	Property	Results
1	90 – micron sieve residue	1.88%
2	Sp. Gr. of Cement	3.14

The fineness test of cement 1.88% and which is permissible limits as the per IS standards. The lower the sieve retention, finer the cement particles and the better hydration and strength development. The specific gravity of cement exhibited to be 3.14 which is close to the normal value for OPC. This indicates the suitability of the cement for investigation. The cement, as per test results, is good in quality and consistency for making concrete. The desired workability & strength properties can be obtained by proper specific gravity (SG) & fineness. Hence, it is evident that the cement used was suitable for the preparation of M30 grade concrete mixes.

3.1.2. TEST ON FINE AGGREGATE

Table 2. Test on Fine Aggregates

Sl. No.	Property	Results
1	Fineness Modulus	3.86
2	Zone Classification (IS 383)	Zone – II
3	Specific Gravity	2.65
4	Water Absorption	1.0%

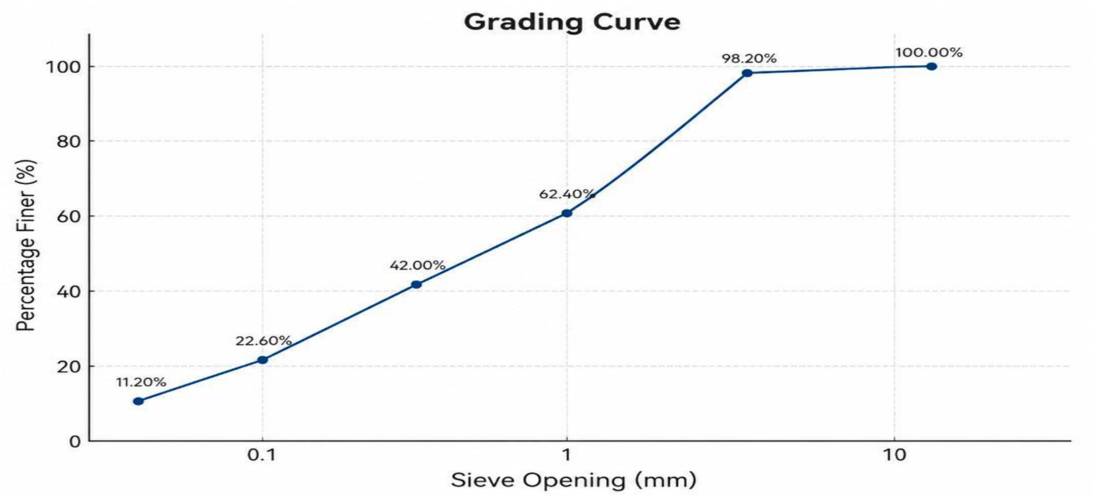

Fig 3 Fineness Modulus of the Fine Aggregate.

The (FA) Fine Aggregate has a fineness modulus of 3.86 which is an evidence that the sand is well graded and suitable for concrete making. The sand is classified as Zone-II as per IS 383 and it is generally used for reinforced concrete works. The specific gravity on fine aggregate was found to be 2.65, which is the normal range for natural river sand. The water absorption of 1.0% indicated low porosity and high quality aggregate. The lower the water absorption, higher the durability of concrete and easier to maintain the desired water to cement ratio. The test results showed that fine aggregate is suitable for the preparation of concrete with satisfactory workability and strength

3.1.3. TEST ON COARSE AGGREGATE:

Table 3 Test on natural coarse aggregate and demolished concreate waste aggregate

Sl. No.	Property	Natural Coarse Aggregate	Demolished Concrete Waste Aggregate
1)	Fineness Modulus	2.60	2.60
2)	Zone Classification (IS 383)	Zone II	Zone II
3)	Specific Gravity	2.65	2.56
4)	Water Absorption (%)	1.01	2.38
5)	Aggregate Impact Value(%)	30.00	27.69

The coarse aggregate properties on natural aggregate and waste aggregate from demolished concrete were studied and compared. The aggregate was found that well grade and acceptable for concrete making with a fineness modulus (2.60). The aggregate is known as Zone-II as per the codal requirement of the IS 383. NCA has a specific gravity of 2.657, whereas the (SG)specific gravity of waste aggregate from demolished concrete is 2.5614. The [SP] specific gravity of recycled aggregate is lower because of the adhering mortar. Natural aggregate water absorption – (1.01%) & recycled aggregate water absorption - (2.38%) which indicates that recycled aggregates are more porous. The total impact value of 30% and 27.69% is a sign of good toughness. Overall, it was confirmed that the (RCA) recycled aggregate can be used part-replacement of concrete.

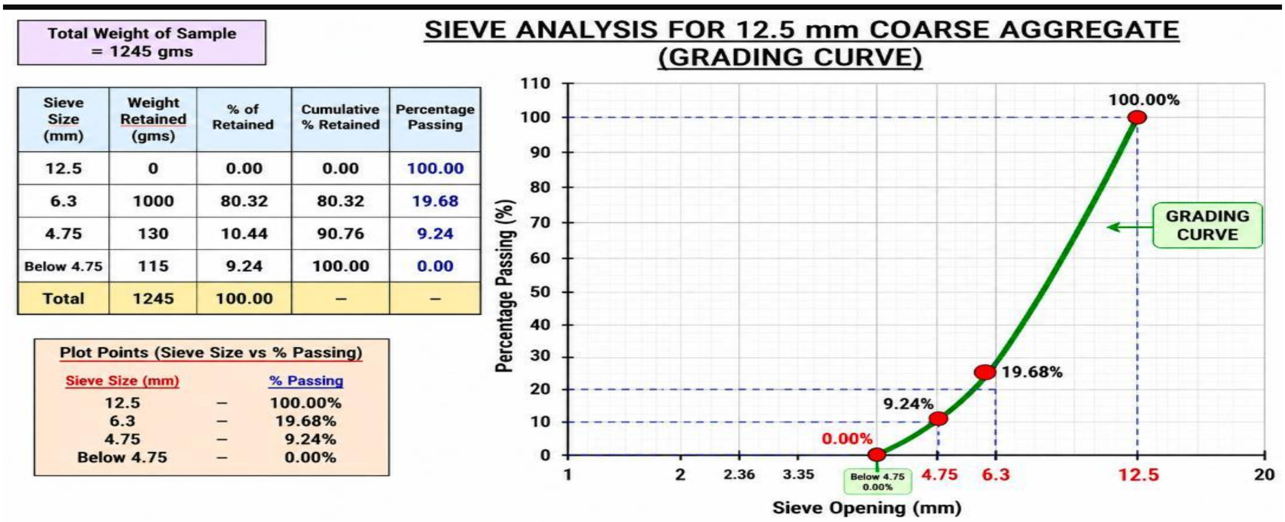

Fig 4 Sieve Analysis for the Coarse Aggregate

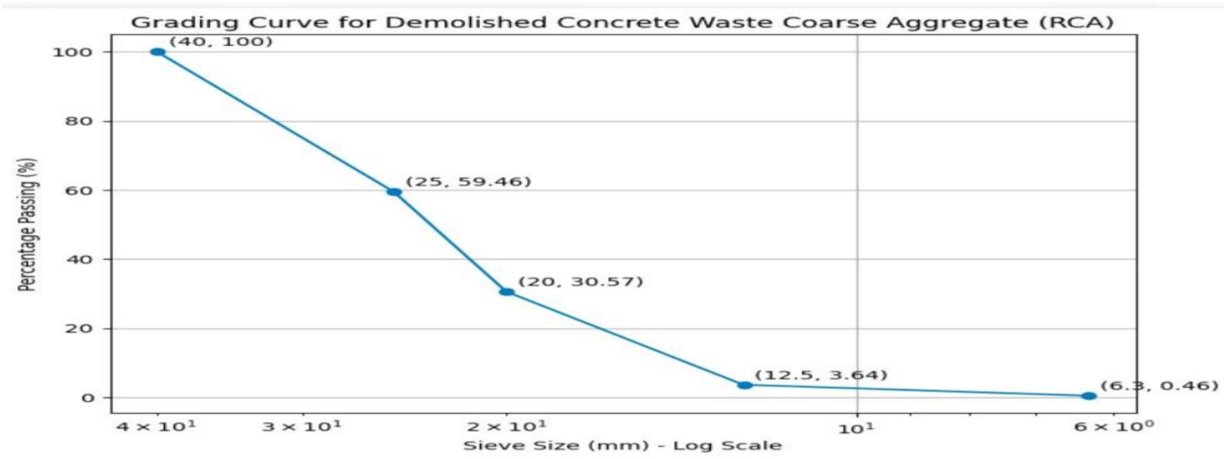

Fig 5 Sieve Analysis of Demolished Concrete Waste

3.1.4. TEST ON FRESH CONCRETE:

Table 4: Slump Test on Fresh Concrete.

Sl. No	Mix Type	Slump Value in mm	Workability
1	Normal Concrete (0% RCA)	29	Medium
2	25% (RCA) Concrete	26	Medium
3	50% (RCA) Concrete	23	Low to Medium

The slump decreased with increase in demolished concrete waste aggregate, Normal concrete exhibited higher Workability, whereas RCA showed lower slump due to more water absorption, roughness surface texture of demolished concrete waste aggregates.

3.1.5 TEST ON HARDENED CONCRETE:

Compression test on Normal Concrete Cubes, 25% Demolished Concrete Cubes and 50% Demolished Concrete Cubes.

Table 5 Compression Test on Cubes

Sl. No	Curing period	Normal Concrete (0%RCA) N/mm²	25% Demolished concrete waste N/mm²	50% Demolished Concrete waste N/mm²
1	7 Days	24	23.4	21.2
2	14 Days	29.1	27.9	26.1
3	28 Days	38	36.6	34.1

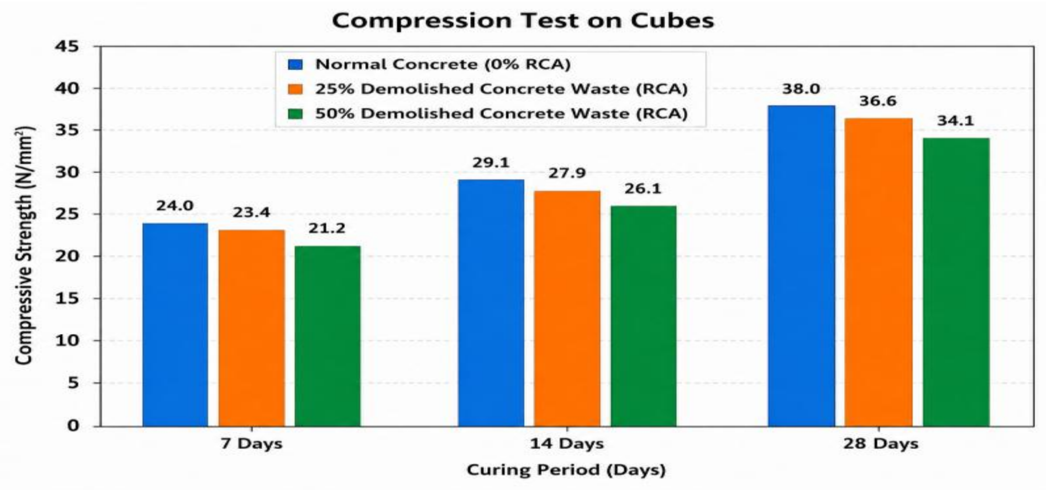

Fig 6: Compression test on cube.

The crushing strength results showed that strength gain was observed in all concrete mixes with curing age. The crushing strengths of the regular concrete (0% RCA) at 7, 14 & 28 days were 24 N/mm 2, 29.1 N/mm 2 and 38 N/mm 2 respectively. Concrete with 25% of demolished concrete waste attained the strengths of 23.4 N/mm2, 27.9 N/mm2 and 36.6 N/mm2 and concrete with 50% replacement attained the strengths of 21.2 N/mm2, 26.1 N/mm2 and 34.1 N/mm2. The results indicate all mixtures exhibit good strength development with curing, but increase in RCA concentration slightly reduces the compressive strength.

3.1.6 COST ANALYSIS

Cost analysis for partial replacement of the (NCA) Natural Coarse Aggregate with Demolished Concrete waste aggregate for M30grade of concrete was done to evaluate the economic feasibility. The quantities of the mix design analysed for 1 m³ of a concrete. Material Cost Estimation Market prices of cement, (FA)Fine Aggregate, (NCA)Natural Coarse Aggregate & Demolished Concrete Waste Aggregate were considered.

Table 6 Cost Analysis for 1 X 106 cm3 of Concrete

Sl. No	Material	Unit Rate per kg	Normal Concrete (0% RCA)	25% RCA	50% RCA
1	Cement	8.00	3304	3320	3336
2	Fine Aggregate	1.50	956	954	951

3	Natural Coarse Aggregates	1.20	1368	1024	680
4	Demolished Concrete Waste Aggregate	0.60	0	164	329
5	Total Cost in Rupees		5628	5462	5296

Table 7 Cost Savings Compared with Normal Concrete

Sl. No	Mix Type	Total Cost in Rupees	Cost Saving in Rupees	Percentage of Saving (%)
1	Normal Concrete	5628	-	-
2	25% RCA Concrete	5462	166	2.95
3	50% RCA Concrete	5296	332	5.90

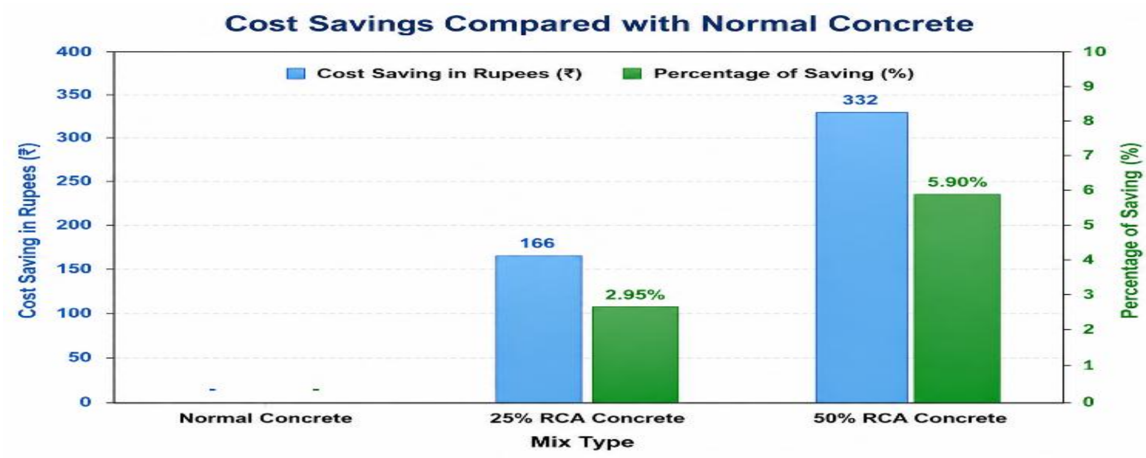

Fig 7: Cost savings compared with normal concrete

As per the cost research, the total cost of concrete production is reduced by using the leftover aggregate of demolition concrete. For 25% RCA concrete, the cost saving was 2.95% (₹166 per cubic meter) as analyzed to conventional concrete. Like wise the 50% RCA concrete resulted in price reduction of 5.90% or ₹332 per cubic meter.

The main reason for the cost reduction is that recycled demolished concrete aggregate is cheaper than natural coarse aggregate. Recycled aggregate has economic benefits such as reducing landfill disposal, conserving natural aggregate resources and practicing sustainable building. Thus, the employ of waste aggregate from demolished concrete to be considered as an economic and ecological alternative for concrete production.

The cost analysis shows the economic benefits of replacing the NCA by waste aggregate from demolished concrete. use of 25% RCA concrete provided a good compromise in terms of strength performance and cost savings and 50% RCA Concrete was cast as the most economical of the mixes studied.

CONCLUSIONS

The strength characteristics of M30 grade concrete using demolished concrete waste as a partially replacement to NCA at the substitution level of 25% and 50% respectively.

1) M30 grade concrete mixwere successfully developed for conventional concrete and for 25% and 50% substitution of demolished concrete waste for natural coarse aggregate as per IS 10262:2009. The mixes were able to develop the necessary workability and strength properties.
2) The slump values for normal concrete were 29 mm and for 25% replacement were 26 mm and for 50% replacement were 23 mm. The results indicate that with the increasing volume of demolished concrete waste, the workability decreases due to its rough surface roughness and enhanced water absorption.

3) All concrete mixes showed an increase in compression strength with curing age. The compressive strengths at 28 days were 38.0 N/mm 2 for normal concrete, 36.6 N/mm 2 for 25% replacement and 34.1 N/mm 2 for 50% replacement. This shows that the strength development in RCA was satisfactory.
4) Normal concrete has maximum crushing strength at all curing times. But the strength of the concrete with 25% of demolished concrete waste has only slightly decreased and remained near the M30 concrete target strength. Although there was a considerable reduction in compressive strength when 50 % replacement was used, the strength is still compliant with standard field requirements.
5) The cost study states the use of the RCA reduces the use of (NCA)natural coarse aggregates reducing overall concrete material expenses. Therefore, recycled aggregate concrete has economic and environmental advantages.

The results of the study show that the natural coarse aggregate existing in M30 concrete can be replaced partly with waste from crushed concrete. Optimum balance between strength, workability, economy and sustainability among the compositions studied is 25% replacement. Use of RCA encourages sustainable building, helps reduce the volume of development & demolition waste that ends up in landfills and helps conserve natural resources.

SCOPE FOR THE FUTURE STUDY

1) Durability tests like carbonation resistance, water absorption, permeability, chloride penetration and sulphate as sault can be done on full scale.
2) It can be investigated to what extent 100 % demolished concrete waste aggregate can be used to produce concrete.
3) Economic and the environmental impact evaluations can assess the sustainable benefits of concrete with recycled aggregate.
4) Further microstructure studies using SEM and XRD may give insights into the bonding properties of recycled aggregate and cement paste.

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